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APPLICATION NUMBER: *60/362,930*
FILING DATE: *March 11, 2002*

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PTO/SB/16 (02-01)
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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No.

INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Robert	KLINE	Richmond Hill, CANADA
Michael	SHENFIELD	Richmond Hill, CANADA

☐ *Additional inventors are being named on the ___ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

SYSTEM AND METHOD OF PRE-EMPTIVELY PUSHING DATA TO A MOBILE DEVICE

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

☐ Customer Number [ ] → *Place Customer Number Bar Code Label here*

OR *Type Customer Number here*

☑ Firm *or* Individual Name	Krishna K. Pathiyal, Esq.
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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 29

☐ CD(s), Number

☑ Drawing(s) *Number of Sheets* 5

☑ Other (specify) Power of Attorney

☐ Application Data Sheet. See 37 CFR 1.76

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees

☑ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-1995

☐ Payment by credit card. Form PTO-2038 is attached.

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

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Respectfully submitted,

SIGNATURE [signature]

Date 03/08/02 (MM/DD/YY)

TYPED or PRINTED NAME Krishna K. Pathiyal, Esq.

REGISTRATION NO. (if appropriate) 44435

TELEPHONE (519) 888-7465 (Ext 2535)

Docket Number: PUS-0543

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

Jc658 U.S. PTO

PTO/SB/17 (10-01)
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TOTAL AMOUNT OF PAYMENT ($) 160.00

Complete if Known	
Application Number	
Filing Date	
First Named Inventor	Robert KLINE
Examiner Name	
Group Art Unit	
Attorney Docket No.	PUS-0543

METHOD OF PAYMENT

1. ☑ The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:

Deposit Account Number: 50-1995

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☑ Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17

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FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	740	201	370	Utility filing fee	
106	330	206	165	Design filing fee	
107	510	207	255	Plant filing fee	
108	740	208	370	Reissue filing fee	
114	160	214	80	Provisional filing fee	160.00

SUBTOTAL (1) ($) 160.00

2. EXTRA CLAIM FEES

			Extra Claims		Fee from below		Fee Paid
Total Claims		-20** =		X		=	
Independent Claims		- 3** =		X		=	
Multiple Dependent						=	

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	84	202	42	Independent claims in excess of 3
104	280	204	140	Multiple dependent claim, if not paid
109	84	209	42	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($)

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FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	400	216	200	Extension for reply within second month	
117	920	217	460	Extension for reply within third month	
118	1,440	218	720	Extension for reply within fourth month	
128	1,960	228	980	Extension for reply within fifth month	
119	320	219	160	Notice of Appeal	
120	320	220	160	Filing a brief in support of an appeal	
121	280	221	140	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,280	241	640	Petition to revive - unintentional	
142	1,280	242	640	Utility issue fee (or reissue)	
143	460	243	230	Design issue fee	
144	620	244	310	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Processing fee under 37 CFR 1.17(q)	
126	180	126	180	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	740	246	370	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	740	249	370	For each additional invention to be examined (37 CFR § 1.129(b))	
179	740	279	370	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) ____

*Reduced by Basic Filing Fee Paid SUBTOTAL (3) ($)

SUBMITTED BY				Complete *(if applicable)*	
Name *(Print/Type)*	Krishna K. Pathiyal, Esq.	Registration No. *(Attorney/Agent)*	44435	Telephone	(519) 888-7465 x 2535
Signature				Date	03/ 08 /02

(MM/DD/YYYY)

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RIM

VIA COURIER March 8, 2002

BOX PROVISIONAL APPLICATION
Assistant Commissioner for Patents
Washington, D.C. 20231
USA

Dear Sir:

Re: **NEW PROVISIONAL PATENT APPLICATION**
Title: **SYSTEM AND METHOD OF PRE-EMPTIVELY PUSHING DATA TO A MOBILE DEVICE**
Inventor(s): **Robert Kline; Michael Shenfield**
Our Ref: **PUS-0543**

Enclosed in connection with this new provisional patent application are the following:

			Number of Pages
(1)	Provisional Application for Patent Cover Sheet (including fee payment and method)		1
(2)	Fee Transmittal Sheet		2
(3)	Specification		29
(4)	Drawing(s)	No. of Figures: 5	5
(5)	Power of Attorney		2
(6)	Receipt Card		1

Payment of Fees:

In sum, please charge the following fees to our **deposit account** as indicated on the Cover Sheet:

Filing fee of $160.00

Yours very truly,

Krishna K. Pathiyal
Patent Agent

Encl.

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SYSTEM AND METHOD OF PRE-EMPTIVELY PUSHING DATA TO A MOBILE DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is directed toward an advanced method of pre-emptively pushing information to be used automatically at a mobile data communications device ("mobile device"). The pushed information could be appended to traditionally pushed information as a result of an information pull request by the mobile device. One standard method for performing pull requests is to use a standard known as Wireless Application Protocol (WAP). The solution proposed here can be used with WAP, HTML (HyperText Markup Language), cHTML (compressed HTML), xHTML (Extensible HTML), XML (Extensible Markup Language) and many other information standards and protocols that have been used in the past, or may emerge. Some aspects of the present invention are also applicable to enabling select pre-emptively pushed information to be used automatically at a mobile device.

2. Description of the Related Art

Immobile data access techniques are well known and have enjoyed an immense success to the benefit of immobile users. These techniques are practised for instance on networked personal computers connected to a wide area network (WAN), such as the Internet. The WAN is typically a collection of wired local area networks (LANs) such as corporate networks or small office/home office (SOHO) networks, with the occasional singleton host computer, all of which are typically connected to the WAN via signals carried over a wire or fibre.

In sharp contrast, a typical mobile user may be disappointed with some aspects of current mobile data access techniques. Known mobile data access techniques may appear to suffer from

latency, narrower bandwidth, and less reliable data connections. These inconveniences reflect the fact that mobile data technology typically has a wireless component: a mobile device is typically connected to the WAN via signals carried wirelessly, such as using radio frequency (RF) waves or infrared (IR).

Traditional wireless technology may have limitations such as signal propagation delays, limited RF spectrum, and signal fade-outs, each of which may account at least in part for the higher latency, narrower bandwidth, and less reliable data connections respectively experienced by mobile data users.

Furthermore, the mobility of a mobile device may make mobile users less predictable than immobile users, as a mobile user may access data from virtually anywhere at virtually any time.

There is a need for mobile infrastructure that enhances the mobility paradigm, while mitigating some of the aforementioned inconveniences.

There is a further need for techniques that mask the mobile inconveniences from the mobile device user (also referred to hereinafter as a subscriber).

There is yet a further need for a subscriber activity analysis system and method that makes intelligent predictions of a mobile user's actions to pre-emptively push data to the mobile device.

3. Summary of the Invention

According to the present invention, there is provided a system for preemptively pushing data to a mobile device. The system includes a prediction server and a prediction client. The prediction server in turn includes a Data Collection Unit (DCU) a Data Adjustment Unit (DAU), an Analysis and Prediction Unit (APU), and a Data Preparation and Push Unit (DPPU). The prediction client, which is preferably embodied in the mobile device, is a counterpart of the prediction sever, the client consisting of a State Reporting Agent (SRA), and a Data Store (DS) 320 for pushed data, both of which are configured top operate with a plurality of data applications at the mobile device.

According to another aspect of the present invention, there is provided a method of preemptively pushing data to a mobile device includes the steps of receiving a pull request, and sending preemptively pushed data in response to the pull request along with the requested data. Optional steps include subscriber activity modeling, training phases, and operational phases.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an overview of an example communication system in which a mobile device may be used;

Fig. 2 is a diagram that shows interactions between the different parts of the system;

Fig. 3 shows a weighted graph modeling wireless subscriber activity;

Fig. 4 shows a transition matrix $\boldsymbol{T}$ structure and adjustment process during the training phase; and

Fig. 5 is a schematic diagram of components that could make up a wireless device that could be used as a mobile device with the invention.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring now to Fig. 1, Fig. 1 is an overview of an example communication system in which a mobile device may be used. One skilled in the art will appreciate that there may be hundreds of different topologies, but the simple system shown in Fig. 1 helps demonstrate the operation of the pre-emptive push systems and methods described in the present application.

Fig. 1 shows a data portal **10**, the Internet **20**, a data server **40**, a wireless gateway **85**, wireless infrastructure **90**, a wireless network **105** and a mobile device **100**. The data portal and server used in the example are for WAP, although any traditionally pull-based data portal or server, such as an HTML, cHTML, xHTML, XML servers and portals can be used instead of or at the same time as WAP. In practice, portal **10** and server **40** are functionally equivalent, i.e. a portal is a data server, except that a mobile carrier typically administers portal **10**.

A WAP portal **10** may for example be connected to a carrier or an ISP (Internet Service Provider) on which a user of the system **10** has an account, located within a company, possibly connected to a local area network (LAN), and connected to the Internet **20**, or connected to the Internet **20** through a large ASP (application service provider) such as America Online (AOL). Those skilled in the art will appreciate that the systems shown in Fig. 1 may instead be connected to a wide area network (WAN) other than the Internet, although WAP transfers are commonly accomplished through Internet-connected arrangements as shown in Fig. 1.

The WAP portal **10** may be implemented for example on a network computer within the firewall of a corporation or carrier, a computer within an ISP or ASP system or the like, and acts as one interface for information exchange over the Internet **20**. Intermediate components are not shown in Fig. 1, as they do not directly play a role in the preemptive push described below. WAP

servers such as portal **10** typically extend beyond just WAP serving; they may also include dynamic database storage engines that have predefined database formats for data like calendars, to-do lists, task lists, e-mail and documentation. WAP portal **10** may also provide links to information that it serves, such as deck **17**, as well as to information served by other servers, such as deck **17'** served by WAP server **40**.

The wireless gateway **85** and infrastructure **90** provide a link between the Internet **20** and wireless network **105**, collectively forming an exemplary information transfer mechanism. The wireless infrastructure determines the most likely network for locating a given user and tracks the user as they roam between countries or networks. A WAP deck **17**, for instance as requested by a mobile device user, is delivered to the mobile device via wireless transmission, typically at a radio frequency (RF), from a base station in the wireless network **105** to the mobile device **100**. The particular network **105** may be virtually any wireless network over which information may be exchanged with a mobile device.

As shown in Fig. 1, mobile device **100** sends a Uniform Resource Identifier (URI) URI0 **15** corresponding to a resource request from portal **10**. This URI **15** is exemplary, as substantially the same behavior occurs if mobile device **100** sends a URI request to any server **40** located somewhere on the Internet **20**. Thus URI0 **15** is, for instance a WAP request for WAP deck0 **17**. The URI0 request **15** arrives to the portal **10** and is normally responded to by portal **10** sending WAP deck **17** to the mobile device **100**. These techniques are all well known to those skilled in the art. Most known systems support this so-called "pull" access scheme, wherein a mobile device must request that the portal send the deck to the device.

Regardless of the specific information transfer mechanism controlling the sending of decks to a mobile device **100**, the deck **17**, is sent via the wireless gateway **85**. The wireless infrastructure **90** includes a series of connections to wireless network **105**. These connections could be Integrated Services Digital Network (ISDN), Frame Relay or T1 connections using the TCP/IP protocol used throughout the Internet. As used herein, the term "wireless network" is intended to include three different types of networks, those being (1) data-centric wireless networks, (2) voice-centric wireless networks and (3) dual-mode networks that can support both voice and data communications over the same physical base stations. The newest of these combined dual-mode networks include, but are not limited to (1) the Code Division Multiple Access (CDMA) network that has been developed and is operated by Qualcomm, (2) the Groupe Special Mobile or the Global System for Mobile Communications (GSM) and the General Packet Radio Service (GPRS) network both developed by the standards committee of CEPT, and (3) the future third-generation (3G) networks like Enhanced Data-rates for Global Evolution (EDGE) and Universal Mobile Telecommunications Systems (UMTS). GPRS is a data overlay on the very popular GSM wireless network, operating in virtually every country in Europe. Some older examples of data-centric network include the Mobitex™ Radio Network, which has been developed by Eritel and Ericsson of Sweden, and is operated by BellSouth (Cingular) Wireless Data in the United States and Rogers/Cantel in Canada, and the DataTAC™ Radio Network, which has been developed by Motorola and is operated by American Mobile Satellite Corporation (AMSC), now called Motient, in the United States and Bell Mobility in Canada. Examples of older voice-centric data networks include Personal Communication Systems (PCS) networks like CDMA, GSM, and TDMA systems that have been available in North America and world-wide for nearly 10 years.

The simple system shown in Fig. 1 illustrates two cases. First, the case where the URI0 **15** requested deck0 **17** is transferred to the mobile device is illustrated. This case is known in the art, and will not be discussed any further.

Finally, the case where not only deck **17** is transferred to the mobile device, but also pre-emptive information **18** is "pushed" along with deck0 **17** in accordance with the present invention, is illustrated. Pre-emptive information **18** in the WAP example illustrated includes at least one pre-emptive URI1 **15'** and deck1 **17'**, whose request was predictably anticipated in accordance to the present invention. For instance, URI1 **15'** could be related to a link found in deck0 **17** of server **10.** As illustrated, URI **15'**, if requested by the mobile device **100,** would traditionally result in deck1 **17'** being sent to mobile device **100.** If the user of mobile device 100, after receiving pre-emptive information **18** requests URI1 **15'**, mobile device **100** need not actually make the request as deck1 **17'** is already available at the mobile device **100.** According to this aspect of the invention, a traditional request is pre-empted according to the present invention, thereby reducing user perceived latency at the mobile device **100.** This case will be described in greater detail with reference to Figs. 2 to 4 below.

Fig. 2 is a diagram that shows interactions between the different parts of the system in an exemplary prediction client/server embodiment. The server side of the system will be described first, after which the client side of the system will be described.

The server side of the system consists of a prediction server **200**, which as illustrated in the example of Fig. 2 is embodied in the wireless gateway **85** of Fig. 1. The example prediction server includes the following components:

- Data Collection Unit (DCU) **210**
- Data Adjustment Unit (DAU) **220**

- Analysis and Prediction Unit (APU) **230**
- Data Preparation and Push Unit (DPPU) **240**

The client side of the system consists of a prediction client **300**, which as illustrated in the example of Fig. 2 is embodied in the mobile device **100**, and is a counterpart of sever **200**, the example client **300** consisting of:

- State Reporting Agent (SRA) **310**
- Data Store (DS) **320** for pushed data (browser cache or mobile application-specific)

Also illustrated is data application **330**, which may optionally be, but preferably is not a part of, the prediction client **300**. Application **330** cooperates with prediction client **300**, for instance, by checking DS **320** for cached information before issuing a data pull request. In the example of WAP, data application **330** is a WAP browser.

The Data Collection Unit (DCU) **210** consists of two main parts: the device state listener and the state storage component (not shown in the drawing). When the mobile device is reporting a new state, the state listener receives the data (device ID and state URI (Universal Resource Identifier)) and redirects it to the state storage component. In alternate embodiments, the device state listener could be implemented as one of the following: socket server, stream connection listener, or servlet. The device state listener could be embodied using software as a stand-alone process or as a thread within the DCU **210** or prediction server **200**. The state storage component consists of the raw data storage of states received from the device state listener (waiting for processing) and hierarchical data storage of states structured according to the user(s) historical activity patterns. Raw data storage is short lived and transient, hierarchical data storage

is persistent and could be implemented using a relational or object database, XML data store, or serialized files.

The Data Adjustment Unit (DAU) **220** is notified when a new state reaches the raw data storage of the DCU **210**. The DAU **220** removes the state URI and device ID from the raw data storage and then pools the corresponding historical data from the DCU's hierarchical data storage. It transforms the data according to a prediction algorithm, such as for example Markov weighted probabilities, two-way sorting, etc., and stores the data back to the DCU **210**. In a preferred embodiment of the DAU **220**, software carries out the steps of the method and uses two separate threads – one for new state notification, and another for state processing.

The Analysis and Prediction Unit (APU) **230** is notified when the DAU **220** completes processing of a new state. It pools corresponding data from the DCU **210**, and using the prediction algorithm makes an intelligent prediction of the most likely user navigation steps following the current device **100** state. The inventors envisage the use of at least 3 distinct prediction modes: atomic, group, and mixed. Atomic mode operates with the historical information of a single user (device) or relatively small group of homogeneous users, and makes predictions based on this information only. Group mode operates with a much greater data sample collected on a large user population. Mixed mode operates with the user specific data first and, if there is not enough information to make a strong prediction (e.g. either the preference pattern is not recognizable or the sub-graph has not yet been visited by the user), it switches to the group mode data to make a prediction. Each prediction mode has its benefits and drawbacks and, therefore, mode selection should depend on the uniformity level of the user population and application specifics, as would be apparent to a person skilled in the art.

The Data Preparation and Push Unit (DPPU) **240** receives a collection of forecasted state URIs from the APU **230**. A method at the DPPU **240** executes the following steps:

- Pulls URI data from the Internet or corporate intranet. This step can be optimized with content caching (subject to the expiration parameters in the content header).

- Prepares push data: packs URIs into a single buffer (device and gateway specific) for transmission to the device. The DPPU method can also perform some additional optimization steps (e.g. content trans-coding or compression) if required.

- Redirects prepared data to a mobile gateway (server) to execute the push to the device.

Some of the tasks in the second step are subject to the availability of mobile gateway **85** (server) capabilities and could be executed by the gateway rather than the prediction server in alternate embodiments.

The device side State Reporting Agent (SRA) **310** interacts with a particular device application **330** (e.g. mobile browser) and gets notified when a user requests a specific URI. When notified, the SRA **310** uses the wireless connection (connection type depends on the device and wireless infrastructure specifics as described above in reference to Fig. 1) to transmit URI data to the server side DCU **210**.

Device Data Store (DS) **320** interacts with a push connection agent (or with any available push notification mechanism) to receive the set of URI data transmitted by the server. In alternate embodiments, the DS **320** could work either as stand-alone data storage for a single application/multiple applications, or as a mediator that passes data along to the prediction event listeners of the applications registered with the DS **320**. In the case of correct prediction

(prediction hit), the user's next selection will be satisfied from the local device storage with virtually zero latency.

A method will now be described in reference to Fig. 2, the method including the steps of:

Step **1** - new state notification, whereby SRA **310** sends state information to DCU **210**;

Step **2** - new state recorded, whereby DCU **210** notifies DAU **220**;

Step **3** - transition matrix adjusted, whereby DAU **220** adjusts the transition matrix and notifies DCU **210**;

Step **4** - new state notification, whereby DAU **220** notifies APU **230**;

Step **5** - pattern analysis, whereby DCU **210** and APU **230** co-operate to recognize subscriber activity patters or trends;

Step **6** - data request for preemptive push, whereby APU **230** requests data to be pushed by DPPU **240**;

Step **7** - data query from Internet / corporate Intranet, whereby DPPU **240** receives data to be pushed; and

Step **8** - data set compilation and push to mobile device, whereby DPPU **240** pushes data to mobile device.

Also shown is optional step 9 whereby device application **330** issues a traditional data pull request (DPR), which can be used as a trigger for initiating any one or several of the steps 1 through 8 described above.

Referring now to Fig. 3, Fig. 3 shows a weighted graph modeling wireless subscriber activity provided in accordance with the present invention. A mobile subscriber activity model can be described by a weighted directional graph, as illustrated in Fig. 3, where each edge

represents two directions. As illustrated, if an edge exists between any two arbitrary vertices A and B, then the edge represents both transition from vertex A to B and from B back to A, and has a pair of associated weights (W_{AB}, W_{BA}), one weight per direction. For example, the edge connecting vertices V1 and V2 has weights (W_{12}, W_{21}). The vertices Vk in the graph correspond to the information states of a wireless device and represent atomic information units like cHTML or xHTML pages, WAP decks, data screens, etc... In this regard, the edges denote bi-directional transitions between the information states. There is a pair of numeric weights associated with each edge. In alternate embodiments, the weight could represent the number (or frequency) of transitions along each direction of the edge during the observation (or training) period. It could also represent any other decision supporting measure based on subscriber historic activity.

The goal of the present method is to predict most likely subset of future transitions (edges) and information units (vertices) based on the current information state of the mobile device (zero vertex) and historically accumulated user activity data represented by edge weights. When the most likely set of future information units is identified, it is pushed to the mobile device to minimize data access latency observed by a subscriber by preferably pre-empting pull requests before they occur.

There are a vast variety of mathematical models that could be used to implement a self-learning system. Given a strong directional pattern of the graph and probability driven decision process for transitions from each vertex, as would be apparent to a person skilled in the art. In the present description, a Markov chain model will be described.

The weighted directional graph of Fig. 3 can be adapted as a Markov chain by ensuring that edge weights are probabilities of transitions between states (vertices). To accomplish this step, the activity graph should be normalized in order for each vertex to have the total weight of

outgoing edges to be equal to 1. The resulting model will operate with the Markov chain states corresponding to atomic units of information (e.g. cHTML or xHTML documents, WAP decks, data screens, etc.) and transitions that represent mobile user navigation from one information unit to another, i.e. URI requests which are to be predictably pre-empted.

Ordinarily, a Markov chain model with n states $S=\{s_1, s_2, \ldots s_n\}$ is fully described by a state vector Z_t and transition matrix T. At any discrete moment t the state of the system can be stochastically defined using the formula:

$$Z_t = T\, Z_{t-1} = T^{t-1}\, Z_0 ,$$

where Z_0 is an initial state of the chain.

Consider a further specification of a Markov chain model that is a history-determined Markov chain. Unlike regular or state-determined chain, the future state of history-determined Markov chain is described by not only the current state of the chain but rather by a finite sequence of preceding states. This class of Markov chains is better suited to model dynamic systems and the preferred candidate model for the self-learning system aspect provided according to the present invention. For a generic history–determined chain the state vector can be defined as:

$$Z_t = F(Z_{t-1}, Z_{t-2}, \ldots, Z_{t-k}),$$

where F is a state transformation function and k is a history "depth".

The set $(Z_{t-1}, Z_{t-2}, \ldots, Z_{t-k})$ is a historic states pattern. Learning algorithms using historic states patterns are preferable over single states as prediction results will better.

Next, consider the following specification of a wireless environment model:

- Cardinality of a Markov chain model for a generic multi-user environment is virtually indefinite: $\lim_{t\to\infty}|S_t| = \infty$, and tends to cover the whole sample space Ω;

- Cardinality of a Markov chain modeling an activity of a single user or a homogeneous group of users is much smaller and a vector of states $S_t = \{s_1, s_2, \ldots s_n\}$ at any given time t represents only a tiny subset of Ω.

- For a single user model (or a homogeneous group of users) the following assumption is correct (stochastic limitation of a state set cardinality):
    - if θ_t is an *observed* state of the model at a moment t then:
    - $\forall \rho \to 0\ \exists n < \infty : P\{\theta_t \in S_t\} > 1 - \rho$ and $|S|_t < n$,

      where $P\{A\}$ is the probability of event A.

Training phase:

Referring now to Fig. 4, Fig. 4 shows a transition matrix $\boldsymbol{T}$ structure and adjustment process during the training phase.

The following method could be used for the dynamic adjustment of the states vector $\boldsymbol{S}$ and transition matrix $\boldsymbol{T}$ **430** :

- Introduce collection frames **410**. A collection frame is a time interval over which the model operates without changing $\boldsymbol{S}$ or $\boldsymbol{T}$. At the end of each frame **410** the collected data is analyzed and $\boldsymbol{S}$ and $\boldsymbol{T}$ are adjusted for the next frame. During the training phase **420**, model space $\boldsymbol{S}$ is likely to grow, in operational phase $|S|$ will likely stay steady even though the individual states might be added or removed reflecting user activity pattern changes. Frame size is expected to change in transition from training to operational phase: it is likely to grow till the system achieves stability.
- To adjust $\boldsymbol{S}$ at the end of the collection frame use frequency based approach: if state θ was visited by the system at least $\boldsymbol{K}$ times during the past frame the state is added to vector $\boldsymbol{S}$. If state θ was not visited by the system during the past $\boldsymbol{M}$ frames the state is removed from $\boldsymbol{S}$. Removal of unused (rarely used) model states is needed to ensure performance efficiency of the method. Optimal values of $\boldsymbol{K}$ and $\boldsymbol{M}$ depend on application specifics and size of controlled user group.

P^r_{ls} - is a transition probability from state l to s as per matrix **430** state at the end of frame r.

The following method step details the transition matrix adjustment process.

- At the end of collection frame **410** frequency matrix F represents state transitions during this frame:

$$\left| \begin{matrix} 0 & f_{12} & \dots & f_{1n} \\ f_{21} & 0 & \dots & f_{2n} \\ \dots & & & \\ f_{n1} & f_{n2} & \dots & 0 \end{matrix} \right| \qquad \boldsymbol{F} =$$

where:

- f_{ij} is a frequency of transitions from state i to state j
- n is a number of model states monitored during past collection frame: includes existing model states and new states visited more than K (threshold value) times during past collection frame.

Introduce weight coefficient α that represents a "refresh rate" for the transition matrix F.

Then the matrix T could be frame-adjusted using the following formula:

$p_{ij} = \alpha f_{ij} + (1-\alpha)\, p_{ij}$, if i existed prior to the past frame

$p_{ij} = f_{ij}$, otherwise

Note: The formula above is identical to $T = \alpha F + (1-\alpha)\, T$ if transition matrix T is zero-extended for the new states prior to calculation.

The weight coefficient α should be adjusted during training and operational phases, α -> *0* as the model matures.

To complete adjustment process we will remove unused (rarely used) states:

- remove rows for unused states – no further adjustment required.
- remove columns for unused states – requires probability normalization:

$P_{ij} = P_{ij} / \sum_{j<m} P_{ij}$, where m is a new number of states.

Transition to operational phase

Next consider steps for calculating t_s - the saturation point when the system migrates from the training to operational phase:

$$\Omega \, (\Delta T)_n < \mathrm{X},$$

where

Ω is a metric defined on the matrix ΔP

$(\Delta T)_n$ is a matrix of probability adjustments over the last collection frame n

X is a saturation point criterion.

For the purpose of this description, let X be a predefined scalar number that represents a quantitative upper boundary for the frame-to-frame transition matrix T adjustment and Ω be a norm defined on the matrix ΔT.

The following two matrix norms are suggested for this purpose:

- The Hilbert-Schmidt norm (sum of square differences):

$$|\Delta T|_2 = \sqrt{\sum_{i,j} (\Delta t_{ij})^2} < X \qquad (I)$$

- The L1 maximum absolute column sum norm:

$$|\Delta T|_1 = \max_j \sum_{i=1..n} |\Delta t_{ij}| < X \qquad (I)$$

Either of these norms provide a condition (I) for the selected matrix to satisfy over a number of consecutive frames, thereby triggering the system to change into an operational state.

Prediction

Prediction steps allow the system to forecast subscriber actions based on the current mobile device state and historically collected data about states space (*S*) and transitional probabilities between states (*T*).

General approach:

To describe the general steps for prediction process first define the variables:

- Prediction depth W is a maximum number of information units (Markov chain states) that is time / price efficient to direct to the mobile device during one push.
- Transition path Z_n is a set of ordered states $Z_n=\{z_1, z_2, z_3, \ldots z_n\}$ $n<W$

  Examples:

  i. (consequent) $x \to z_1 \to z_2 \to z_3 \to \ldots \to z_n$

  ii. (parallel) $x \to z_1 \to z_2$

  $$x \to z_3 \to \ldots \to z_k$$
  $$x \to z_2 \to z_5 \to \ldots \to z_n$$

  where x is a current state of a mobile device.

  The goal of the prediction steps is to predict an optimal (based on the historic data) path Z_n and push to the mobile device states $z_1, \ldots z_n$

- Probability metric P_{Zn} is a composite probability measure defined on the set Z_n to identify an optimal path out of all possible paths.
- Cost function C_k represents a cost of push data transmission for k pages
- Weight function $F_{Zn} = P_{Zn} + \beta C_n$, where β is a cost weight coefficient.

For every new state of the mobile device an algorithm solves optimization problem maximizing F_{Zn} over all possible Z_n sets: $n<W$

The pre-emptive push occurs when the $F_{Zn} > R_0$, where R_0 is a push validity threshold.

Next consider an extreme example of this general algorithm:

$$C_k = 0,\ W = 1$$

$$F_{Zn} = P_{Zn} = P_{Z_1}$$

$$P_{Z_1} = Pxi \qquad (\, i \in S,\ \ x \text{ is a current device state})$$

The resulting $Z_1 = \{i\}$: $\quad Pxi = \max_{j \in S} (Pxj),\ i \in S$

Pushing just a single data unit to the mobile device might prove practical for some information formats (e.g. WAP decks), but in most cases it is much more valuable to produce an extended forecast. Let's broaden the first example to the case when $W > 1$:

$$C_k = 0,\ W > 1$$

$$F_{Zn} = P_{Zn}$$

Let's introduce variable r_0 as a path selection threshold: state transition $i \to j$ is selected if

$Pij > r_0$.

Next define a selection process for a "candidate" set $\mathbf{Z}^c$:

1. Select all states $z_1 : Pxz_1 > r_0$ and add them to the set $\mathbf{Z}^c$

2. For the states z_1 from step 1 select all states z_2: $Pz_1z_2 > r_0$ and add them to the set $\mathbf{Z}^c$ while keeping path references (i.e. $x \to z_1 \to z_2$)

3. Continue the selection process till either $|\mathbf{Z}^c| = \mathbf{W}$ (simple case – no optimization required) or path length exceeds $\mathbf{W}$: ($x \to z_1 \to z_2 \ldots \to z_W$) or selection process cannot find any transition with $Pz_kj > r_0$ at the step $k < \mathbf{W}$.

If $|\mathbf{Z}^c| \leq \mathbf{W}$, then $\mathbf{Z}_n = \mathbf{Z}^c$ – no optimization required.

If $|\mathbf{Z}^c| > \mathbf{W}$, then

$$\mathbf{Z}_n \in \mathbf{Z}^c : \mathbf{P}_{Zn} = max_{n \leq W} \mathbf{P}(\mathbf{Z}^c)$$

Probability measure $\mathbf{P}$ can be defined as a simple sum of transition probabilities along the paths in $\mathbf{Z}^c$. For more generic $\mathbf{P}$ it should be ensured that while finding a maximization subset of candidate set $\mathbf{Z}^c$, the transition paths are kept intact, i.e. if the state z_m is chosen then all the states in a path from x to z_m are to be chosen as well.

Note: An alternate approach in $\mathbf{Z}^c$ selection is to increase threshold r_0 as the selection process moves away from the origin (current device state). This approach could accommodate

both cost considerations C_k and validity threshold R_0 and greatly simplify the prediction process.

Wireless Device:

Fig. 5 is a schematic diagram of components that could make up a wireless device that could be used as a mobile device with the invention.

Turning now to Fig. 5 there is a block diagram of a wireless device **900** in which portions of the instant invention may be implemented. The wireless device **900** is preferably a two-way communication device having at least voice and data communication capabilities. The device preferably has the capability to communicate with other computer systems on the Internet. Depending on the functionality provided by the device, the device may be referred to as a data messaging device, a two-way pager, a cellular telephone with data messaging capabilities, a wireless Internet appliance or a data communication device (with or without telephony capabilities).

Where the device **900** is enabled for two-way communications, the device will incorporate a communication subsystem **911**, including a receiver **912**, a transmitter **914**, and associated components such as one or more, preferably embedded or internal, antenna elements **916** and **918**, local oscillators (LOs) **913**, and a processing module such as a digital signal processor (DSP) **920**. As will be apparent to those skilled in the field of communications, the particular design of the communication subsystem **911** will be dependent upon the communication network in which the device is intended to operate. For example, a device **900** destined for a North American market may include a communication subsystem **911** designed to operate within the Mobitex mobile communication system or DataTAC mobile communication

system, whereas a device **900** intended for use in Europe may incorporate a General Packet Radio Service (GPRS) communication subsystem **911**.

Network access requirements will also vary depending upon the type of network **919**, such as Wireless Network **105** of Fig. 1. For example, in the Mobitex and DataTAC networks, mobile devices such as **900** are registered on the network using a unique personal identification number or PIN associated with each device. In GPRS networks however, network access is associated with a subscriber or user of a device **900**. A GPRS device therefore requires a subscriber identity module (not shown), commonly referred to as a SIM card, in order to operate on a GPRS network. Without a SIM card, a GPRS device will not be fully functional. Local or non-network communication functions (if any) may be operable, but the device **900** will be unable to carry out any functions involving communications over network **919**. When required network registration or activation procedures have been completed, a device **900** may send and receive communication signals over the network **919**. Signals received by the antenna **916** through a communication network **919** are input to the receiver **912**, which may perform such common receiver functions as signal amplification, frequency down conversion, filtering, channel selection and the like, and in the example system shown in Fig. 9, analog to digital conversion. Analog to digital conversion of a received signal allows more complex communication functions such as demodulation and decoding to be performed in the DSP **920**. In a similar manner, signals to be transmitted are processed, including modulation and encoding for example, by the DSP **920** and input to the transmitter **914** for digital to analog conversion, frequency up conversion, filtering, amplification and transmission over the communication network **919** via the antenna **918**.

The DSP **920** not only processes communication signals, but also provides for receiver and transmitter control. For example, the gains applied to communication signals in the receiver **912** and transmitter **914** may be adaptively controlled through automatic gain control algorithms implemented in the DSP **920**.

The device **900** preferably includes a microprocessor **938**,, which controls the overall operation of the device. Communication functions, including at least data and voice communications, are performed through the communication subsystem **911**. The microprocessor **938** also interacts with further device subsystems such as the display **922**, flash memory **924**, random access memory (RAM) **926**, auxiliary input/output (I/O) subsystems **928**, serial port **930**, keyboard **932**, speaker **934**, microphone **936**, a short-range communications subsystem **940** and any other device subsystems generally designated as **942**.

Some of the subsystems shown in Fig. 5 perform communication-related functions, whereas other subsystems may provide "resident" or on-device functions. Notably, some subsystems, such as keyboard **932** and display **922** for example, may be used for both communication-related functions, such as entering a text message for transmission over a communication network, and device-resident functions such as a calculator or task list.

Operating system software used by the microprocessor **938** is preferably stored in a persistent store such as flash memory **924**, which may instead be a read only memory (ROM) or similar storage element (not shown). Those skilled in the art will appreciate that the operating system, specific device applications, or parts thereof, may be temporarily loaded into a volatile store such as RAM **926**. It is contemplated that received communication signals may also be stored to RAM **926**. flash memory **924** preferably includes data communication module **924B**, and when device **900** is enabled for voice communication, voice communication module **924A**.

For the purposes of this invention, are also included in flash memory **924** other software modules **924N**, which are also shown as prediction client **300** of Fig. 2.

The microprocessor **938**, in addition to its operating system functions, preferably enables execution of software applications on the device. A predetermined set of applications which control basic device operations, including at least data and voice communication applications for example, will normally be installed on the device **900** during manufacture. A preferred application that may be loaded onto the device may be a personal information manager (PIM) application having the ability to organize and manage data items relating to the device user such as, but not limited to e-mail, calendar events, voice mails, appointments, and task items. Naturally, one or more memory stores would be available on the device to facilitate storage of PIM data items on the device. Such PIM application would preferably have the ability to send and receive data items, via the wireless network. In a preferred embodiment, the PIM data items are seamlessly integrated, synchronized and updated, via the wireless network, with the device user's corresponding data items stored or associated with a host computer system. Also preferred is a browser application, such as device application **330** of Fig. 2. Further applications may also be loaded onto the device **900** through the network **919**, an auxiliary I/O subsystem **928**, serial port **930**, short-range communications subsystem **940** or any other suitable subsystem **942**, and installed by a user in the RAM **926** or preferably a non-volatile store (not shown) for execution by the microprocessor **938**. Such flexibility in application installation increases the functionality of the device and may provide enhanced on-device functions, communication-related functions, or both. For example, secure communication applications may enable electronic commerce functions and other such financial transactions to be performed using the device **900**.

In a data communication mode, a received signal such as a text message or web page download will be processed by the communication subsystem **911** and input to the microprocessor **938**, which will preferably further process the received signal for output to the display **922**, or alternatively to an auxiliary I/O device **928**. A user of device **900** may also compose data items such as e-mail messages for example, using the keyboard **932**, which is preferably a complete alphanumeric keyboard or telephone-type keypad, in conjunction with the display **922** and possibly an auxiliary I/O device **928**. Such composed items may then be transmitted over a communication network through the communication subsystem **911**.

For voice communications, overall operation of the device **900** is substantially similar, except that received signals would preferably be output to a speaker **934** and signals for transmission would be generated by a microphone **936**. Alternative voice or audio I/O subsystems such as a voice message recording subsystem may also be implemented on the device **900**. Although voice or audio signal output is preferably accomplished primarily through the speaker **934**, the display **922** may also be used to provide an indication of the identity of a calling party, the duration of a voice call, or other voice call related information for example.

The serial port **930**, would normally be implemented in a personal digital assistant (PDA)-type communication device for which synchronization with a user's desktop computer (not shown) may be desirable, but is an optional device component. Such a port **930** would enable a user to set preferences through an external device or software application and would extend the capabilities of the device by providing for information or software downloads to the device **900** other than through a wireless communication network. The alternate download path may for example be used to load an encryption key onto the device through a direct and thus reliable and trusted connection to thereby enable secure device communication.

A short-range communications subsystem **940** is a further optional component which may provide for communication between the device **900** and different systems or devices, which need not necessarily be similar devices. For example, the subsystem **940** may include an infrared device and associated circuits and components or a Bluetooth™ communication module to provide for communication with similarly-enabled systems and devices.

Having described in detail the preferred embodiments of the present invention, including the preferred methods of operation, it is to be understood that this operation could be carried out with different elements and steps. This preferred embodiment is presented only by way of example and is not meant to limit the scope of the present invention.

ABSTRACT

A system for pre-emptively pushing data to a mobile device includes a prediction server and a prediction client. The prediction server in turn includes a Data Collection Unit (DCU)a Data Adjustment Unit (DAU), an Analysis and Prediction Unit (APU), and a Data Preparation and Push Unit (DPPU). The prediction client, which is preferably embodied in the mobile device, is a counterpart of the prediction sever, the client consisting of a State Reporting Agent (SRA), and a Data Store (DS) 320 for pushed data, both of which are configured top operate with a plurality of data applications at the mobile device. A method of pre-emptively pushing data to a mobile device includes the steps of receiving a pull request, and sending pre-emptively pushed data in response to the pull request along with the requested data. Optional steps include subscriber activity modeling, training phase steps, and operational phase steps.

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PTO/SB/81 (02-01)
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Application Number	
Filing Date	
First Named Inventor	Robert KLINE
Title	System And Method of...
Group Art Unit	
Examiner Name	
Attorney Docket Number	PUS-0543

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☐ Assignee of record of the entire interest. See 37 CFR 3.71.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

SIGNATURE of Applicant or Assignee of Record

Name	Michael SHENFIELD
Signature	
Date	March 6, 2002

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Name	Robert KLINE
Signature	Robert Kline
Date	March 6/2002

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☑ *Total of 2 forms are submitted

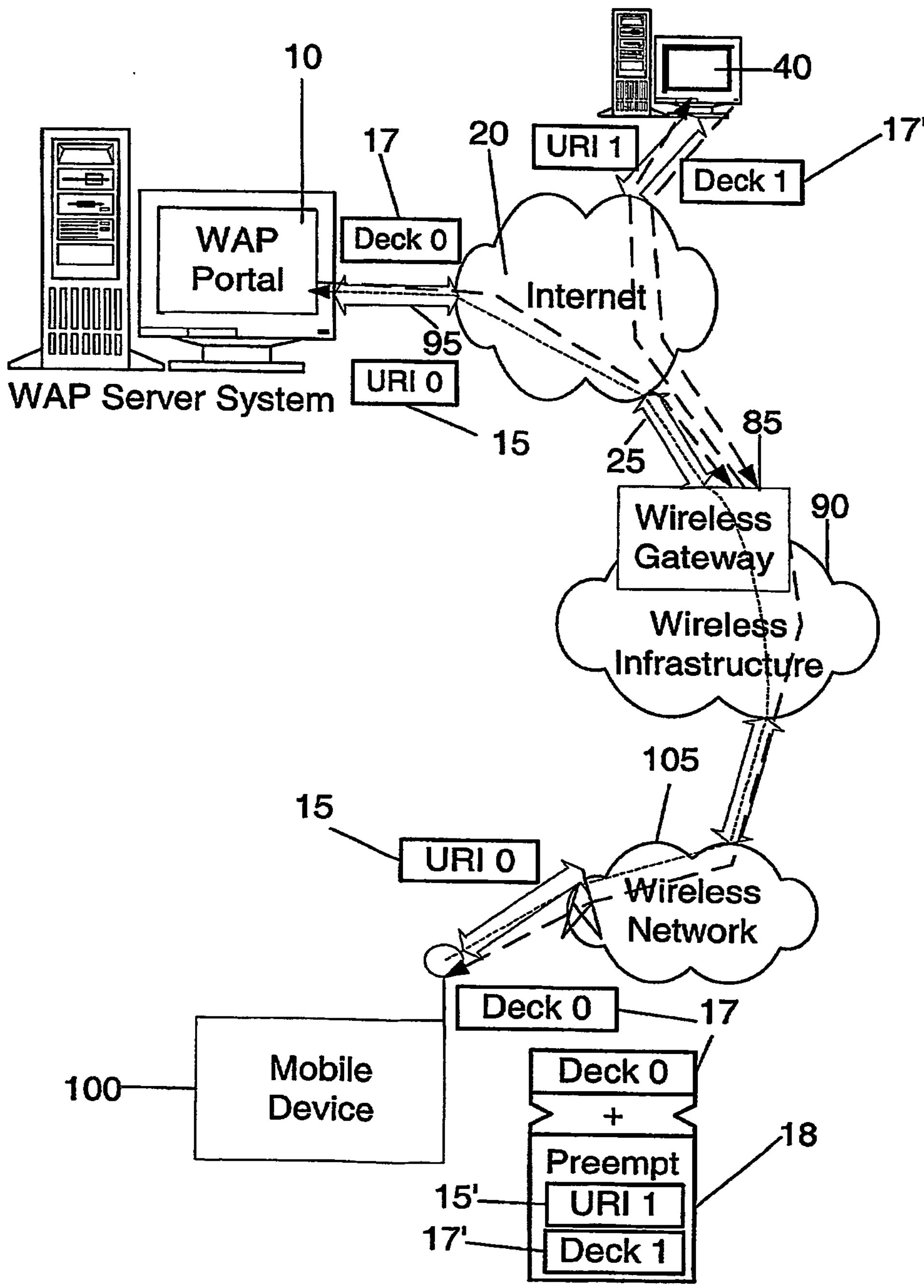
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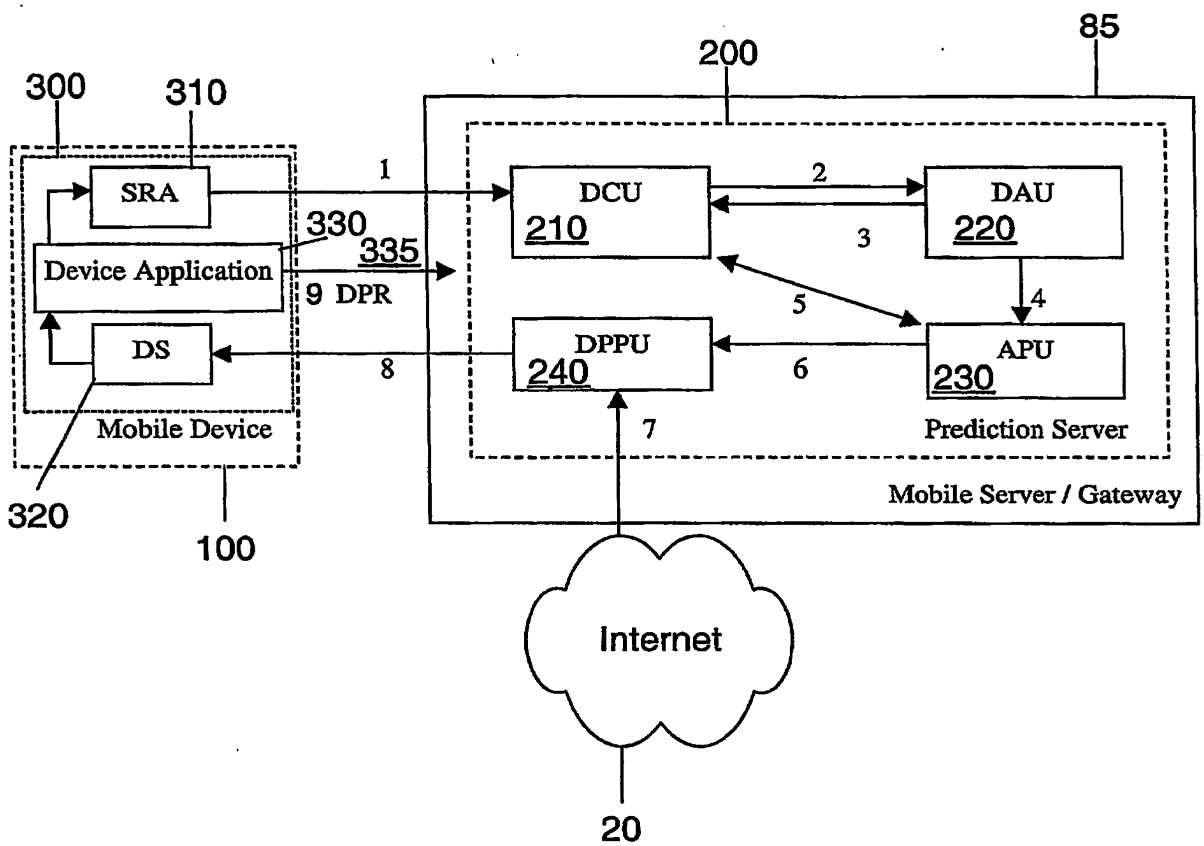
Fig. 1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Prediction Server
Mobile Server / Gateway
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100
Internet
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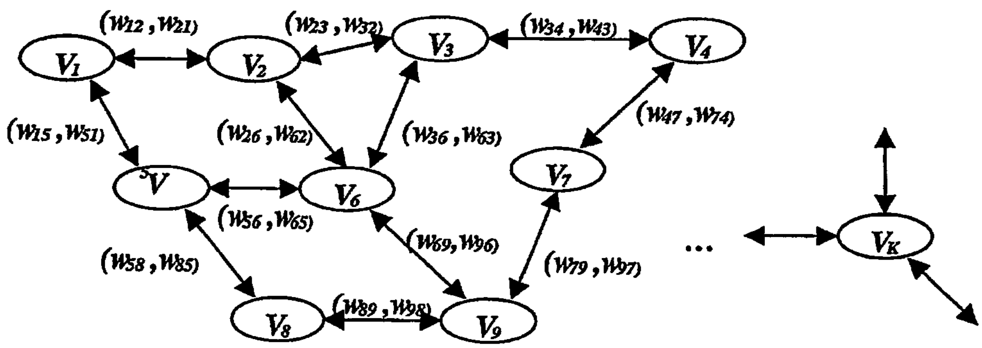
Fig. 2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V9

Fig.3

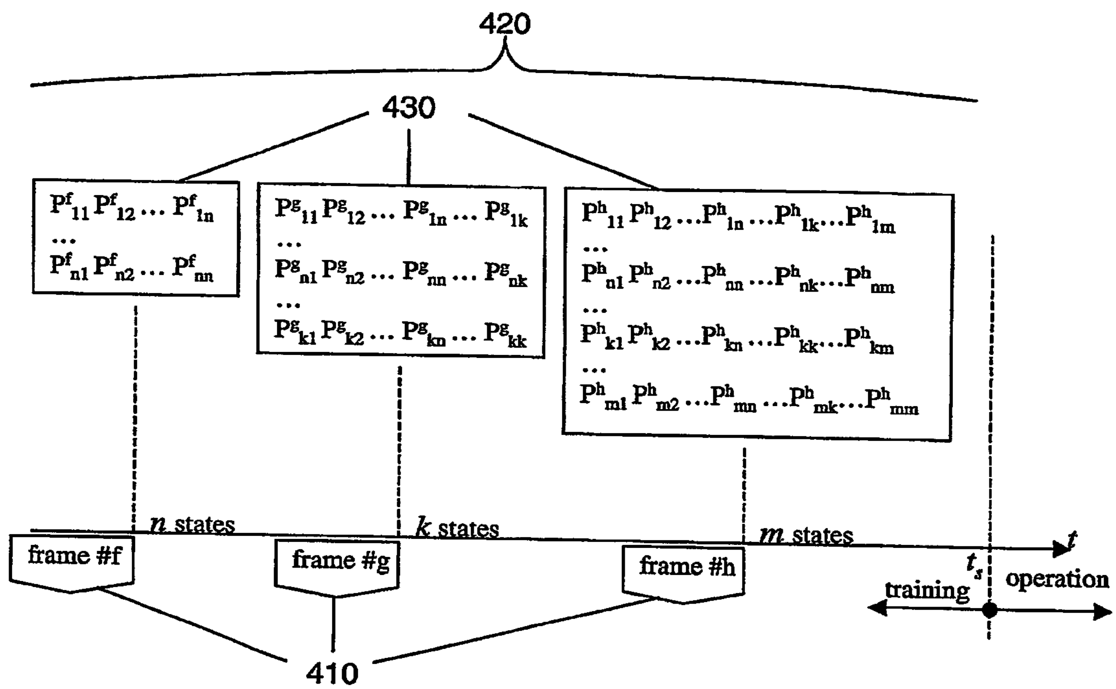
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Fig. 4

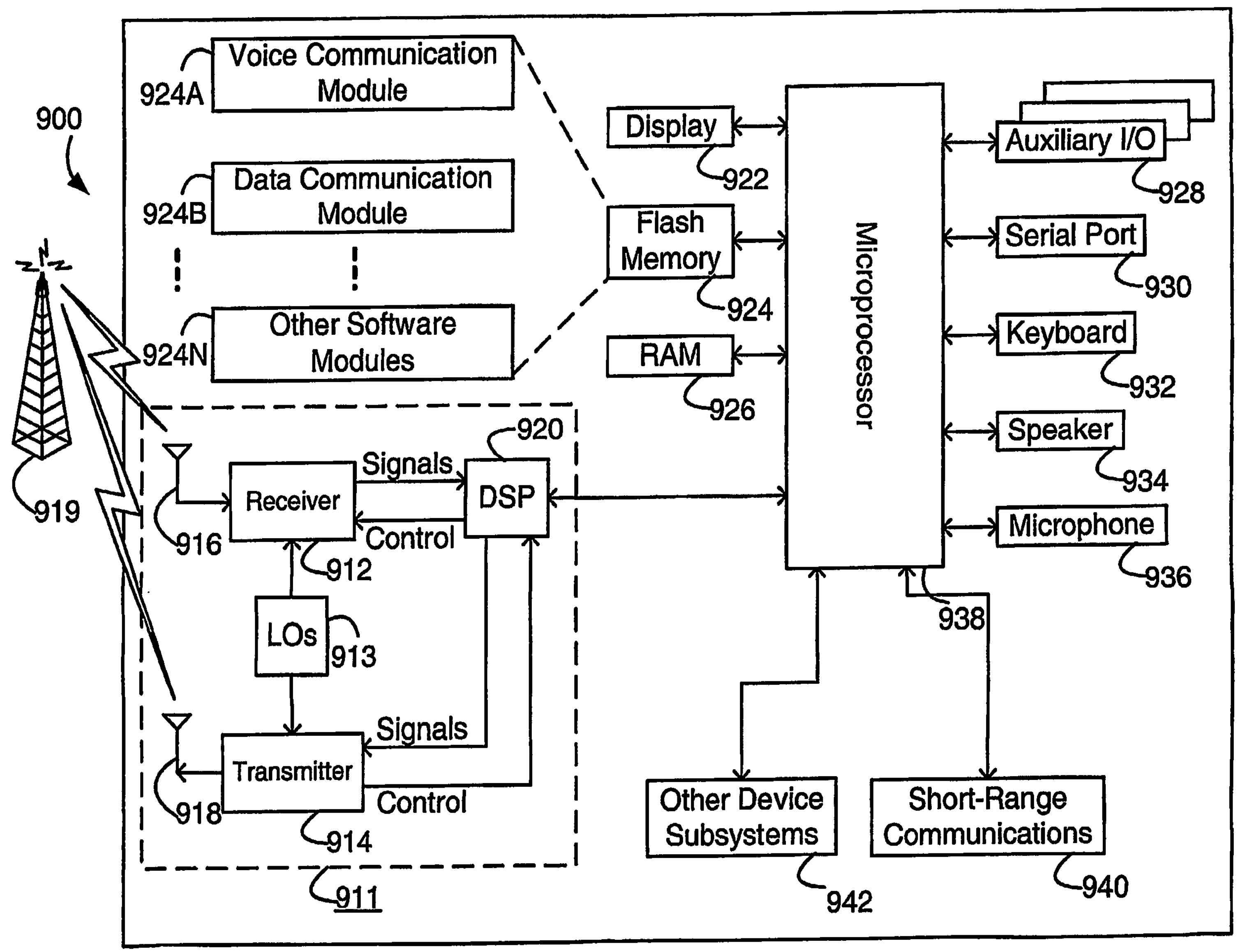
900
919
Voice Communication Module
924A
Data Communication Module
924B
Other Software Modules
924N
Display
922
Flash Memory
924
RAM
926
Microprocessor
Auxiliary I/O
928
Serial Port
930
Keyboard
932
Speaker
934
Microphone
936
938
Receiver
912
916
Signals
Control
DSP
920
LOs
913
Transmitter
914
918
Signals
Control
911
Other Device Subsystems
942
Short-Range Communications
940

Fig. 5